ISSN: 2456-9348
Vol (03) _Issue (05) Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

EXPERIMENTAL INVESTIGATION OF DUAL REINFORCEMENT IN ALUMINUM METAL MATRIX COMPOSITES MANUFACTURED BY STIR CASTING TECHNIQUE

Abhimanyu Mallick
A.Manimaran
Department of Mechanical Engineering, Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu, India
abhimanyu.mallick@gmail.com
mullaimaran@rediffmail.com

ABSTRACT
An attempt was made to experimental investigation of A356 Aluminium metal matrix reinforced with aluminium oxide and boron nitride manufactured by cost effective stir casting technique. Aluminium oxide weight fraction was kept constant as 2% while distinctive weight fractions of boron nitride were utilized, which were vary from 0.5% to 2.0%. The hard powder of reinforcements were pre-heated up to temperature of 300°C and A356 aluminium matrix was melted at 750°C. The pre-heated reinforcements were added in the molten aluminium matrix. Sample specimens were made by stir casting method for carried out experimental works. Tensile test, Hardness test and Microstructural analysis were carried out to find out best suitable compositions with better mechanical properties. The hardness of the composite was increased by increasing the boron nitride content up to 1.5%, after that a noticeable reduction is observed with the increase of boron nitride content. The tensile strength was increased with increasing of boron nitride up to 1.5% and reduction in tensile strength was observed for 2.0% of boron nitride due to agglomeration.

KEYWORDS:
Aluminium metal matrix, stir casting, Reinforcements, Boron Nitride, Mechanical properties.

1. INTRODUCTION

Aluminium Metal Matrix Composites (AMCC) are increasing importance because of its unique combination for low density, good corrosion resistance and excellent mechanical properties. These are used great extent in automobile, aircraft, aerospace and various industrial applications [1]. AMCC are commonly reinforced by, silicon carbide (SiC), Aluminium Oxide (Al_2O_3) and carbon (C) etc. The form of reinforcement are in the flakes, fibers and particulate. The distribution of particle play important role in the properties of aluminium metal matrix composites [2-4]. Reinforcement with Al_2O_3 particulate in aluminium metal matrix has very good comprehensive strength and wear resistance of composites. The porosity of aluminium metal matrix composites increases with increase weight fraction of Al_2O_3. Micro size Al_2O_3 of 7.5% weight in A356 metal matrix occurred agglomeration of reinforcement particles [5].

The aluminium metal matrix reinforced with dual reinforcement has significance improvement on grain structure and mechanical properties [6]. The boron nitride particles as reinforcement for aluminium has been growing considerably due to its self-lubricating property, thermal and chemical stability. The dual reinforcement of Boron carbide (B_4C) and BN particles composites shows improvement in elongation and impact energy [7]. BN mostly used as soft lubricant and has been proven to decrease the coefficient of friction with change in the hardness [8]. The stir casting is generally adopted in promising route and practiced commercially due to simplicity, cost effective and can be applied to large production quantity effectively.

2. MATERIALS USED

2.1 Aluminium A356

Aluminium A356 material high strength to weight ratio and most commonly used aluminium alloy. The specific tensile strength and rigidity are better as compared with other aluminium alloy and excellent casting and machining properties. Constituents of aluminium A356 are Silicon (Si), Iron (Fe), Cupper (Cu), Manganese (Mn), Zinc (Zn), Nickle (Ni) and Titanium (Ti).The chemical composition of Aluminium A356 reported in the Table 1.

ISSN: 2456-9348
Vol (03) _Issue (05) Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

Table 1. Chemical composition of Aluminium A356

Constituent	Si	Fe	Cu	Mn	Mg	Zn	Ni	Ti	Al
Wt. (%)	7.2	0.15	0.03	0.1	0.4	0.07	0.05	0.1	Balance

2.2 Aluminium Oxide

Aluminium oxide (Al_2O_3) is a best ceramic reinforcement for influence in mechanical properties in aluminium metal matrix composites. Al_2O_3 owing abrasive to its hardness and refractory material to its elevated melting point. Al_2O_3 is a good electrical insulator and higher thermal conductivity (30 $Wm^{-1}K^{-1}$) in the ceramic material.

2.3 Boron Nitride

Boron Nitride (BN) is a synthetic intensify that includes equivalent quantities of boron and nitrogen molecules. Boron nitrate exists in different crystalline structures that are isoelectronic to carbon.

3. METHODOLOGY

The stir casting technique is liquid state processing in which the matrix material will be melted and the reinforcement materials will be added to it and stir with graphite made stirrer by suitable mechanism. The stir casting setup as shown in the Figure 1.

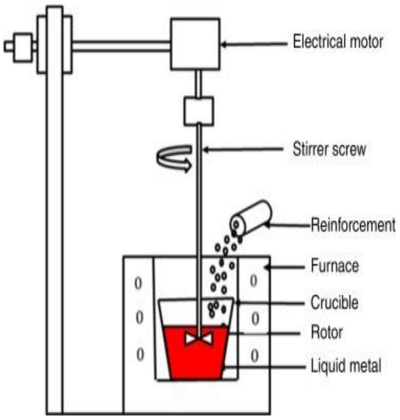


Figure 1. Stir casting setup

Aluminium A356 was cut into small pieces and put into crucible for melting up to 750° C. The Al_2O_3 and BN were preheated at 300° C and added to the molten matrix with different fraction. The mixture were reheated to above melting temperature of aluminium matrix for further agitation and continuous stirring. The stir impeller has rotated with 150 to 300 rpm for period of 4 minutes for uniform distribution of reinforced particles. The semisolid metal matrix composite has poured to metallic mould for preparation of test samples. The samples were made as per the different weight proportion as provided in the Table 2 and the flow diagram for methodology as shown in the Figure 2.

iJETRM
International Journal of Engineering Technology Research & Management

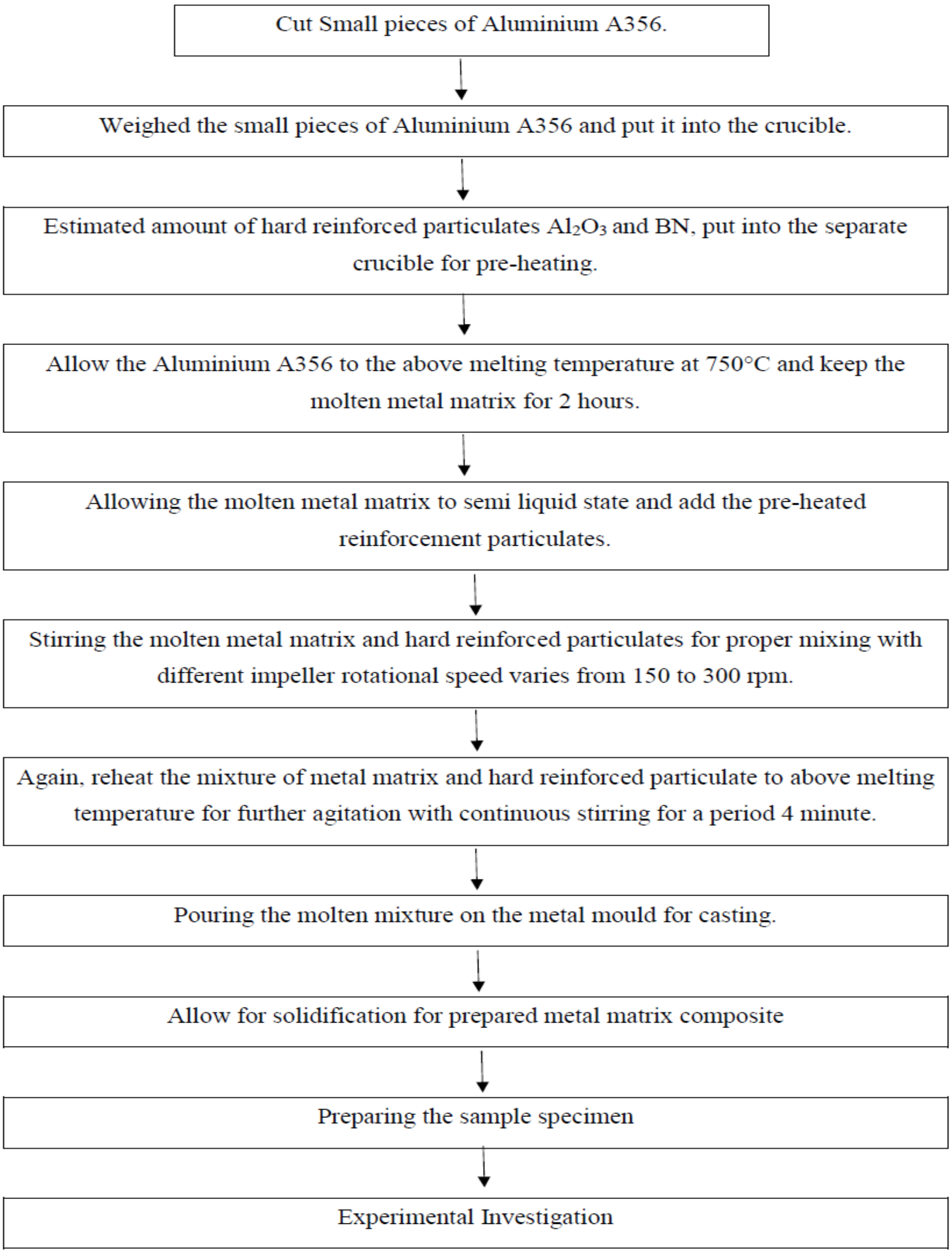


Figure 2. Flow diagram for methodology.

iJETRM
International Journal of Engineering Technology Research & Management

Table 2. Weight proportions of composites

Sl.No.	Sample Name	Aluminium A356 (Weight %)	Al_2O_3 (Weight %)	BN (Weight %)
1	ABN1	97.5	2	0.5
2	ABN2	97	2	1
3	ABN3	96.5	2	1.5
4	ABN4	96	2	2

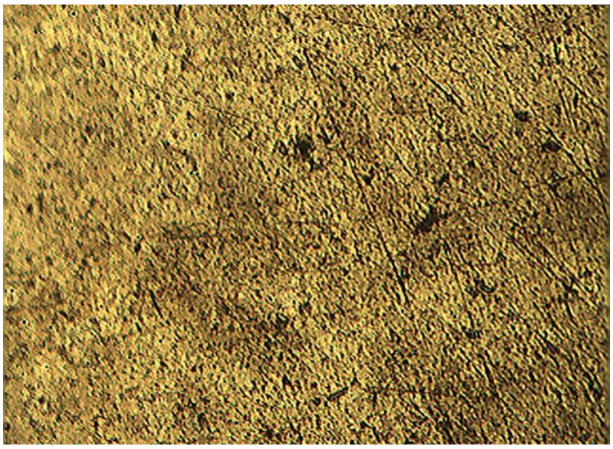
4. MICROSTRUCTURE OF COMPOSITES

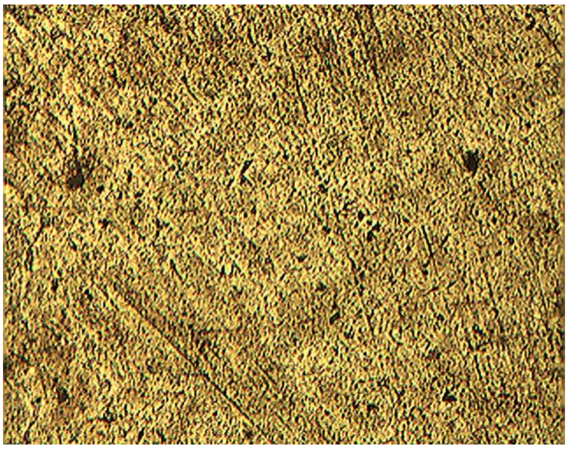
The Scanning Electron Microscopy (SEM) was used to study the microstructural behavior of the composites. SEM shows the dispersions of Al_2O_3 & BN particles in Aluminium matrix. Uniform dispersion of reinforcements were observed in aluminium metal matrix composites reinforced with 2% Al_2O_3 and 0.5% BN. The very fine particles of BN were observed at the grain boundary junctions of primary dendritic grains of aluminium. The microstructural picture of composite reinforced with 2% Al_2O_3 and 0.5% BN as shown in the figure 3 (a).

The distribution of both reinforcements were very large scattered in the aluminium metal matrix and difficult to trace the particles reinforced with 2% Al_2O_3 and 1% BN. The BN particles are more uniformly distributed in the aluminium matrix. No porosities defects are noticed with 100x magnification as show in the figure 3 (b). More uniform distribution of the composite particles observed as the etch process brought the particles to the surface.

The reinforcement particles showed uniform dispersions and close proximity in the aluminium metal matrix solid solution reinforced with 2% Al_2O_3 and 1.5 % BN. The primary shows slow cooled grains and dendrites are larger as the grain sizes are more than 100 microns. More of BN particles observed over Al_2O_3 particles with this proportion of composites. No shrinkage and porosities defects found in 100X magnification as shown in the figure 3 (c).

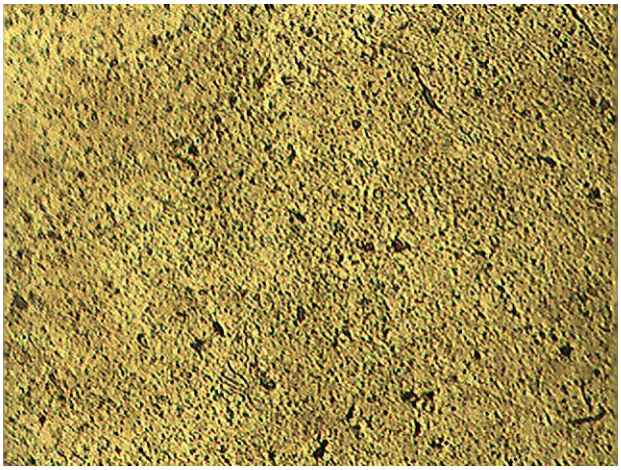
The dark bigger particles of Al_2O_3 particles observed in the composite reinforcement with 2% Al_2O_3 and 2% BN. The Al_2O_3 which was used as dual reinforcement in the composites. The agglomeration of BN particle are seen due to increase weight % fraction in this composites. The composites reinforcement particles are trapped in the grain boundary voids and distinctly distribution is observed in this metal matrix composites. Higher particles of BN is observed due to higher addition in this metal matrix composite. The figure 3 (d) shows the microstructure of composite reinforced with 2% Al_2O_3 and 2% BN.


(a)


(b)

ISSN: 2456-9348
Vol (03) _Issue (05) Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management


(c)

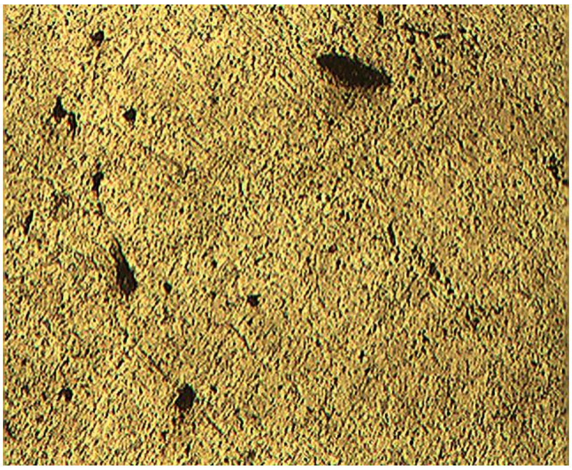

(d)

Figure 3. Microstructures of composites (a) 2% Al_2O_3 & 0.5% BN, (b) 2% Al_2O_3 & 1.0% BN, (c) 2% Al_2O_3 & 1.5% BN, and (d) 2% Al_2O_3 & 2% BN

5. MECHANICAL PROPERTIES

5.1 Hardness test

The hardness test carried out on Vickers hardness testing machine according to ASTM E92 standard. A diamond indenter was equipped in the testing machine. The indenter was in the shape of pyramid with a square base and produces an indentation on the specimen surface. It is observed that hardness was increased with the increase of boron nitride up to 1.5% and after that considerable reduction in hardness was seen. The maximum hardness observed as 75 HV (Hardness in Vickers Scale) and for the composite sample made with 2% of Al_2O_3 and 1.5% of BN (ABN3). The hardness and tensile strength values of composites as shown in the Figure 3

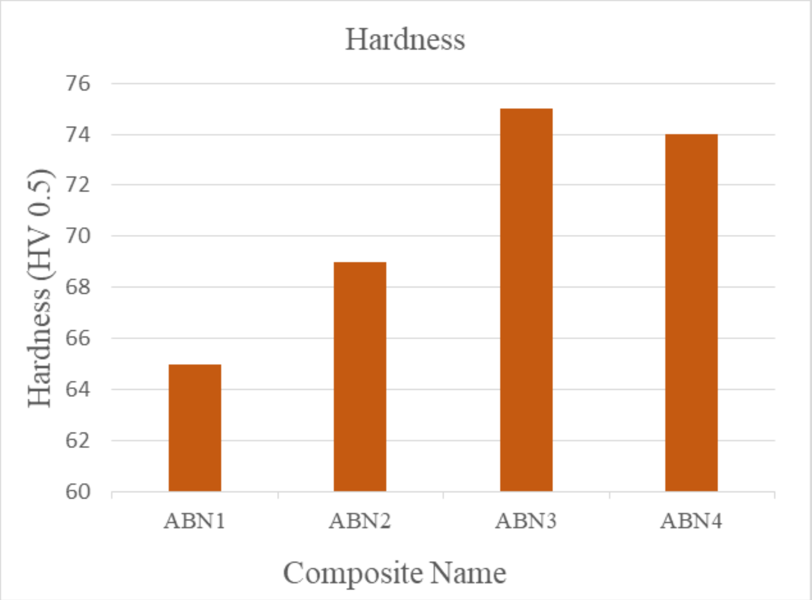


Figure 3. Hardness value of composites

5.2 Tensile test

Tensile test was performed on the sample specimens using universal testing machine. The specimens were machined as per ASTM-E8 standard. The maximum tensile strength was observed as 280 Mpa (Mega Pascals) for the composite of with 2% weight of Al_2O_3 and 1.5% weight of BN. The tensile strength values of composites as shown in the Figure 3 and Figure 4 respectively.

iJETRM
International Journal of Engineering Technology Research & Management

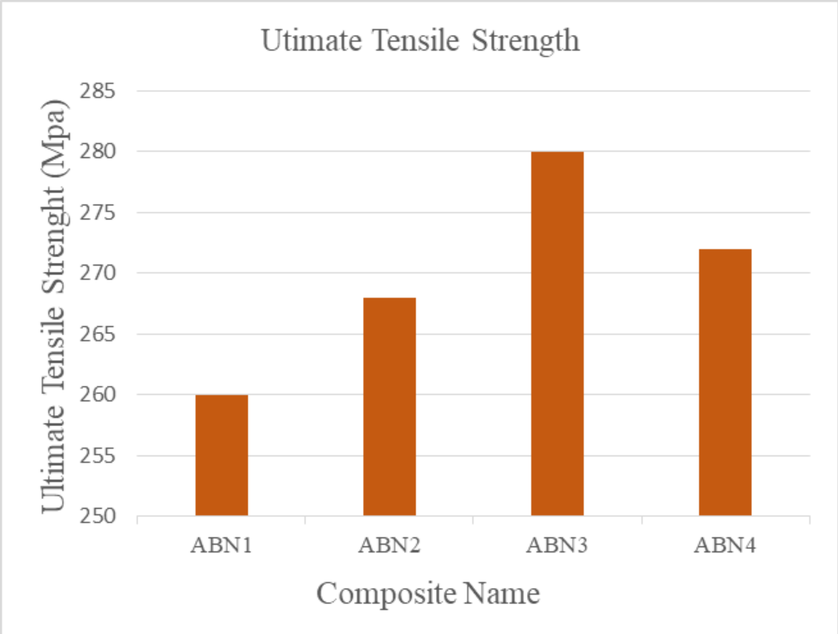


Figure 4. Ultimate Tensile Strength of composites

6. CONCLUSION

The aluminium metal matrix reinforced with Al_2O_3 and BN has been successfully manufactured by stir casting techniques. SEM shows that the dispersions of BN particles in Aluminium matrix is normal. The hardness of the composites were increased with increase boron nitride weight percentage up 1.5%. The maximum hardness was observed as 75 HV for composite reinforced with 2% Al_2O_3 and 1.5% BN. The tensile strength was increased with increasing proportion of BN up to 1.5% weight volume, while reduction in tensile strength for 2% weight volume of BN due to agglomeration particle when increasing the weight percentage. The experimental result shown that composite reinforced with 2% of Al_2O_3 and 1.5% of BN have better mechanical properties.

REFERENCES

[1] Hai Su, Wenli Gao, Zhaohui Feng and Zheng Lu (2012) " Processing, microstructure and tensile properties of nano-sized Al2O3 particle reinforced aluminium matrix composites" Materials and Design 36, 590-596.

[2] Hossein Abdizadeh, Reza Ebrahimifard and Mohammad Amin Baghchesar (2013) "Investigation on mechanical properties and fracture behavior of A356 aluminum alloy based ZrO2 particle reinforced metal-matrix composites' Ceramics International 39, 2045–2050.

[3] Z. Miskovic, and I. Bobic, (2006) "The Structure and Mechanical Properties of an Aluminium A356 Alloy Base Composite with Al2O3 Particle Additions" Tribology in industry, Volume 28, 3-8,

[4] S.A Sajjadi, H.R Ezatpour and H.Beygi (2011) "Microstructure and mechanical properties of Al-Al2O3 micro and nano composites fabricated by stir casting" Material Science and Engineering 528, 8765-8771 .

[5] R Harichandran and N. Selvakumar (2017) "Microstructure and mechanical characterization of (B4C + BN)/Al dual composites processed by stir casting, International Journal of Mechanical Sciences 39, 08-12.

[6] P.Hariharasakthisudhan, S. Jose (2017) "Influence of metal powder premixing on mechanical behavior of dual reinforcement (Al2O3 (mm)/Si3N4 (nm)) in AA6061 matrix" Journal of Alloys and Compounds 731, 100-110.

iJETRM
International Journal of Engineering Technology Research & Management

[7] B.Vijaya Ramnath and C. Elanchezhian (2014) “Aluminium metal matrix Composite-Areview” Advance material Science 38, 55-60.
[8] A.Dehghan Hamedan and M Shahmiri (2012) “Production of A356-1wt.% SiC nanocomposite by the modified stir casting method” Material Science & Engineering A 556, 921-926.
[9] Hanumanthe Gowda and P. Rajendra Prasadb (2012) “Fabrication of A356 composite reinforced with micro and nano Al2O3 particles by a developed compo casting method and study of its properties” Journal of Alloys and Compounds 511, 226– 231.
[10] Hanumanthe Gowda,P and Rajendra Prasadb (2017) “Influence of Heat Treatment on corrosion Resistance of A356/RHA/Al2O3 Based Hybrid Composites”, Materials Today: Proceedings 4, 10870–10878.
[11] Hossein Abdizadeh and Reza Ebrahimifard (2014) “Investigation of microstructure and mechanical properties of nano MgO reinforced Al composites manufactured by stir casting and powder metallurgy methods: A comparative study” Composites: Part B 56, 217–221.
[12] J. Hashim, L.Looney and M.S.J Hashmi (1999) “Metal matrix composites: production by the stir casting method” Journal of Materials Processing Technology 92-93, 1-7.
[13] K.S. Alhawari and M.Z.Omar (2013) “Wear Properties of A356/Al2O3 Metal Matrix Composites Produced by Semisolid Processing” Procedia Engineering 68, 186 – 192.
[14] Lava Kumar Pillari, V. Umasankar and G. Chandrasekhar (2016) “Synthesis and characterization of nano hexagonal boron nitride powder and evaluating the influence on aluminium alloy matrix” Material Today: Proceeding 3, 2018-2026.
[15] M. Karbalaei Akbari and H.R. Baharvandi (2013) “Fabrication of nano-sized Al2O3 reinforced casting aluminum composite focusing on preparation process of reinforcement powders and evaluation of its properties” Composites: Part B 55, 426–432.
[16] M. Karbalaei Akbari and O. Mirzaee (2013) “Fabrication and study on mechanical properties and fracture behavior of nanometric Al2O3 particle-reinforced A356 composites focusing on the parameters of vortex method” Materials and Design 46, 199–205.